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POLLEN MORPHOLOGY OF INDIAN SIMAROUBACEAE

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ABSTRACT

The present work relates to the pollen morphology of Indian taxa belonging to Simaroubaceae. Pollen grains of 18 species of 10 genera have been described, measured and illustrated. Their characteristic features have been summarized and two basic pollen types have been recognized. A key to the pollen grains of the genera examined is also provided. The significance of these pollen characters in taxonomic considerations has been discussed.

INTRODUCTION

Pollen morphology has long been recognised as an important criterion in determining more accurately the natural relationship among some genera and families. Along with other morphological characters, size, shape, class, aperture and surface sculpture of the pollen wall have been considered to be of useful diagnostic value (Wodehouse, 1935; Selling, 1947; Iverson and Troels-Smith, 1950; Erdtman, 1952, 1960 a, 1961; Erdtman and Straka, 1961; Faegri, 1956; Ikuse, 1956: Fasbender, 1959; Punt, 1962 and Kuprianova, 1963). Often it becomes difficult to compare fossil pollen with their reference materials because of the absence of adequate description and key to the modern flora. This is particularly true in India where comprehensive data are lacking. Such identification problem is encountered even in studies on airborne pollen and on pollen loads in honey.

Investigations on the pollen morphology of the family Simaroubaceae so far have been rather scanty (Griebel, 1931; Wodehouse, 1932, 1942, 1945; Ikuse, 1956 and Zander, 1935, 1937, 1941). It is mainly due to the work of Erdtman (1952) that our present day knowledge of the pollen morphology of this family has been greatly enriched. The present study deals with an account of the pollen grains of Indian taxa belonging to Simaroubaceae with a view to getting a correct understanding of their different forms and also to find out their taxonomic significance, if any, in the family.

MATERIALS

Simaroubaceae is mainly a pantropical family and includes about 200 species under 32 genera (Lawrence, 1951). Bennett (1875) recorded from British India 9 genera comprising 17 species. The present investigation is based upon pollen grains obtained from 10 genera distributed over 18 species including those which are now grown in India. The area dealt with comprises British India including Burma, Ceylon and Malay Peninsula.

All materials for this study were collected from following herbaria of the Botanical Survey of India:

1. Central National Herbarium, Calcutta (CNH)
2. Eastern Circle Herbarium, Shillong (ECH)
3. Northern Circle Herbarium, Dehra Dun (NCH)

METHODS AND TERMS

The polliniferous materials were removed from preserved herbarium sheets and the whole mount of the pollen was prepared according to Erdtman's (1960 b) revised 'Acetolysis method'. Pollen residue, to be used mainly for the measurement, was left unbleached. It was mounted in glycerine-jelly under the same cover glass along with acetolysed and chlorinated grains. Samples of the same species derived from different herbarium sheets are of rather uniform nature. Special attention was paid to find out the range of diversity, if any. All grains are described and measured in the swollen condition (Erdtman and Praglowski, 1959).

The range of measurements for the polar axis (P) and equatorial axis (E) given in this account is based on an average of 20 pollen grains. When two measurements are stated for the size of a grain, furrow or pore, the first one is along the polar axis and the second is along the equatorial axis. The length and width of the colpus and the shape and dimension of the os vary even within a species and their measurements are intended to convey a general idea of their sizes and the range of variation within the group. The relative size of the polar field is based on the ratio between the most widely separated furrow apices and the equatorial diameter (Iversion and Troels-Smith, 1950). This is of great value for the description of pollen (Hyde and Adams, 1958, Punt, 1962).

The descriptive terms for the pollen grains are primarily based on Erdtman (1952). The terminology proposed by Faegri and Iverson (1950), Iverson and Troels-Smith (1950), Anonymous (1958), Erdtman and Vishnu-Mittre (1958) and Hyde and Adams (1958) has also been followed, when required.

The pollen slides bearing the accession numbers of their respective herbarium sheets, have been deposited in the Herbarium of the Botanical Survey of India, Calcutta for future reference.

DESCRIPTION OF THE MORPHOLOGY OF THE POLLEN GRAINS

Ailanthus altissima (Mill.) Swingle (*A. glandulosa* Desf.)

Scheme : 1 ; Plate : I, Figs. 1-4

Source and *distribution*: CNH 76901, cultivated in Indian Botanic Garden. Northern India, cultivated in the hills of Punjab, probably introduced.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, medium in size; polar view subtriangular, equatorial view subspherical to elliptical; prolate spheroidal (70%) to subprolate in shape.

Dimension : P : 27 - 36 μ
E : 24 - 30 μ

Mean value for acetolysed grains 31.7 × 26.7 μ and for acetolysed and chlorinated grains 32.5 × 27.1 μ ; distance between widely separated furrow apices 9 μ.

Aperture : 3-colporate, colpi 3, long, broader near the ora at equator and taper gradually towards the poles, about 25 μ long and 3 μ broad; ora 3, one in the middle of each furrow, lalongate, 3 × 8 μ, rectangular in shape, lateral ends rounded, membrane smooth.

Exine : Thick, 3 μ ; sexine as thick as nexine; surface pattern reticulate, evenly distributed over the mesocolpia with distinct LO pattern, brochi near the colpi margins replaced by a striatoid pattern; muri obscurely duplibaculate.

Polar field index : 1 : 3, medium.

Ailanthus triphysa (Dennst.) Alston (*A. malabarica* DC.

Scheme : 2 ; Plate I, Figs. 5-11

Source and *distribution* : CNH 76931 (Thwaites) Ceylon; *Arora* 760 S. Kanara. South Kanara to Cape Coumarin, Bombay, Andamans.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, medium in size; polar view subtriangular, shallowly lobed, equatorial view elliptical to spherical; prolate spheroidal (70%) to subprolate in shape.

Dimension : P : 27.2 - 32 μ
E : 24 - 28.8 μ

Mean value for acetolysed grains 28.9 × 25.3 μ and for acetolysed and chlorinated grains 30.7 × 26 μ ; distance between widely separated furrow apices 8 μ.

Aperture : 3-colporate, colpi 3, long, broader near the ora at equator, about 24 μ long and 3 μ broad, taper gradually towards the poles; ora 3, one in the middle of each furrow, lalongate, about 2.5 × 6.4 μ, varying in shape from rectangular to elliptical, lateral ends rounded, membrane smooth.

Exine : Thick, 3.2 μ ; sexine thicker than nexine, sexine 2 μ thick; surface pattern reticulate, meshes about 3 μ, reticulum simplibaculate, homobrochate with distinct LO pattern; columella about 1 μ.

Polar field index : 1 : 3.2, medium.

Variation : *Arora* 760: Pollen grains spherical in equatorial view, almost equiaxis, prolate spheroidal (85%), rarely subprolate; mean value for the acetolysed grains 26 × 24 μ ; ora 3 × 9 μ; exine near the colpi margins presents a striatoid pattern.

Ailanthus excelsa Roxb.

Scheme : 3 ; Plate I, Figs. 12-14.

Source and *distribution*: CNH 76903, cultivated in Indian Botanic Garden; NCH Dehra Dun. North Western India, Sambalpur, Baroda, Madras, Godavari district.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, medium in size; polar view subtriangular, equatorial view elliptical, sometime polar axis short; subprolate (70%) to prolate spheroidal in shape.

Dimension : P : 33.6 - 40 μ
E : 24 - 32 μ

Mean value for acetolysed grains 35.4 × 29 μ and for acetolysed and chlorinated grains 35.5 × 29.25 μ; distance between widely separated furrow apices 10 μ

Aperture : 3-colporate, colpi 3, rather short, about 28 μ long and 4.8 μ broad, tip acute; ora 3, one in the middle of each furrow, lalongate 3 × 10 μ, rectangular, lateral ends rounded.

Exine : Thick, 3.4 μ ; sexine as thick as nexine or sometimes thicker; surface pattern finely striato-reticulate, faintly curvimurate, bacula short.

Polar field index : 1 : 3, medium.

Balanites aegyptica (L.) Del. (*B. roxburghii* Planch.)

Scheme : 4 ; Plate I, Figs. 15-17

Source and *distribution*: CNH 77402, cultivated in Indian Botanic Garden, and CNH 77397 Etwa. Drier parts of India from South Eastern Punjab and Delhi to Sikkim, Madhya Pradesh, Gujrat, Bombay, Madras, Mysore.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, medium in size; polar view circular, equatorial view elliptical, polar axis long; subprolate (85%) to prolate.

Dimension : P : 28 - 32 μ
E : 21 - 26.5 μ

Mean value for acetolysed grains 30 × 23 μ and for acetolysed and chlorinated grains 30.3 × 23.4 μ; distance between widely separated furrow apices 8 μ.

Aperture : 3-colporate, colpi 3, about 22 μ long and 3-5 μ broad, taper gradually; ora 3, one in the middle of each furrow, elliptical, lolongate, 8 × 5 μ rarely circular 6 μ, membrane smooth.

Exine : Thick, 3μ ; sexine as thick as nexine; surface tectate, faintly striate, oriented parallel to the polar axis, columella about 1.2μ.

Polar field index : 1 : [illegible]8, medium.

Variation : CNH 77397—Mean value for acetolysed grains 37·6×29μ Subprolate (95%). Thickness of the exine is 3.4 μ and sexine is thicker than nexine.

Brucea mollis Wall.

Scheme : 5 ; Plate I, Figs. 18-20.

Source and *distribution*: CNH 77197 (Gallatly) Tenasserim and ECH 4326 (N. L. Bor) Assam. Subtropical Eastern Himalayas, Sikkim, Bhutan, Khasia and Jaintia hills.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, small in size; polar view circular, shallowly lobed, equatorial view elliptical; prolate (60%) to subprolate in shape.

Dimension :　P : 24 - 27μ
E : 16 - 21μ

Mean value for acetolysed grains 25×18.5μ for acetolysed and chlorinated grains 25.6×19μ ; distance between widely separated furrow apices 4.5μ.

Aperture : 3-colporate, colpi 3, about 18 μ long and 3μ broad, tenuimarginate and taper gradually; ora 3, one in the middle of each furrow, rectangular, lalongate 3.5×6.4 μ with lateral ends rounded.

Exine : Thick, 2.5 μ ; sexine thicker than nexine; sexine about 1.5μ, surface pattern striate, oriented parallel to longitudinal axis.

Polar field index : 1 : 4, small.

Brucea amarissima (Lour.) Merr. (*B. sumatrana* Roxb.)

Scheme : 6 ; Plate II, Figs. 21-24

Source and *distribution*: CNH 77166, cultivated in Indian Botanic Garden. Assam, Andaman islands.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, small in size; polar view circular, shallowly lobed, equatorial view elliptical; prolate (98%) in shape.

Dimension :　P : 22.4 - 27.2μ
E : 16　19.2μ

Mean value for acetolysed grain 24×16.4μ and for acetolysed and chlorinated grains 24.8×17.5μ ; distance between widely separated furrow apices 4.8μ.

Aperture : 3-colporate, colpi 3, about 19μ long and 3.5μ broad; ora 3, one in the middle of each furrow, rectangular, lalongate, 3×7μ

Exine : Thick, 2.5μ ; sexine thicker than nexine; surface pattern striate, oriented parallel to the polar axis, slightly curvimurate.

Polar field index : 1 : 3.5, medium.

Eurycoma apiculata Benn.

Scheme: 7 ; Plate II, Figs. 25-27

Source and *distribution* : CNH 77281 (King's collector), Malaya. Malaya.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, small in size; polar view subtriangular, more or less angulaperturate, equatorial view elliptical, prolate (70%) to subprolate in shape.

Dimension :　P : 17.6 - 20.8μ
E : 13 - 19.2μ

Mean value for acetolysed grains 18.8×14.8μ and for acetolysed and chlorinated grains 19.1×16.3μ ; distance between widely separated furrow apices 8μ.

Aperture : 3-colporate, colpi 3, 12μ long and 1.6 μ broad, tip gradually tapers towards the pole, colpi margin covered with small reticulum; ora 3, one in the middle of each furrow, lalongate 1.5×5μ, elliptical, membrane smooth.

Exine : Thick, 2.5μ ; sexine as thick as nexine; surface pattern finely reticulate, meshes about 1.5 μ, hombrochate, simplibaculate, with distinct LO pattern.

Polar field index : 1 : 1.8, medium.

Eurycoma longifolia Jack.

Scheme : 8 ; Plate II, Figs. 28-30

Source and *distribution*: CNH 77246 (Shaik Mokim), Burma. Andaman islands.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, medium in size; polar view subtriangular, more or less angulaperturate, equatorial view elliptical; subprolate (80%) to prolate in shape.

Dimension :　P : 23 - 28.8μ
E : 17.6 - 22.4μ

Mean value for acetolysed grains 25.8×20.6μ ; distance between widely separated furrow apices 5μ.

Aperture : 3-colporate, colpi 3, 20μ long and 2.5μ broad, tip tapers gradually; ora 3, one in the middle of each furrow, lalongate 3×6μ, rectangular in shape.

Exine : Thick, 2.5μ, sexine as thick as nexine or sometime thicker than nexine, surface pattern finely reticulate, meshes about 1.5μ, simplibaculate, homobrochate with LO pattern.

Polar field index : 1 : 4.1, small.

Harrisonia bennetti Hk. f.

Scheme: 9 ; Plate II, Figs. 31-38

Source and *distribution*: CNH 77332 (Lace), Burma, CNH 77353 (Parkinson), Andamans, ECH 4303 (Raizada), cultivated in New Forest, Dehra Dun. South Andamans, Burma.

Symmetry and form : Pollen grain isopolar, 3-zonicolporate, medium in size, rarely large; polar view circular to subcircular, equatorial view elliptical, prolate in shape.

Dimension :　P : 45 - 52μ
E : 32 - 38μ

Mean value for acetolysed grains 49.5 × 33.8μ ; distance between widely separated furrow apices 11μ

Aperture: 3-colporate, colpi 3, about 42μ long and 3μ broad, taper gradually towards the poles; ora 3, one in the middle of each furrow, elliptical, lalongate 5 × 10μ, ends rounded.

Exine: Thick, 3μ ; exine slightly thicker at poles than at equator, sexine thicker than nexine or as thick as nexine, sexine about 2μ; surface pattern reticulate, meshes about 3μ, simplibaculate, in some places duplibaculate, meshes of reticulum smaller near the colpi margin; LO pattern distinct.

Polar field Index: 1 : 3.1, medium.

Irvingia malayana Oliv.

Scheme: 10; Plate II, Figs. 39-40; Plate III, Figs. 41-45

Source and *distribution*: CNH 77317 (Rodger), Burma; CNH 77330 (Kerr), Siam. Burma.

Symmetry and form: Pollen grain isopolar 3-zonicolporate, rarely 4-zonicolporate, small in size; polar view triangular, angulaperturate, equatorial view almost spherical; prolate spheroidal (90%) in shape.

Dimension: P : 18 - 22μ
E : 16 - 20μ

Mean value for acetolysed grains 20 × 18μ ; distance between widely separated furrow apices 7μ.

Aperture: 3-colporate, colpi 3, brevicolpate, about 13 μ long and 1.5μ broad, tenuimarginate; ora 3, lalongate, 6 × 7μ, more or less square (similar type of ora as in *Suriana*), membrane smooth.

Exine: Thick, about 3μ, sexine as thick as or slightly thicker than nexine, surface, finely reticulate, homobrochate.

Polar field index: 1:2.5, medium.

Picrasma andamanica Kurz

Scheme: 11; Pl. III, Fig. 46

Source and *distribution*: CNH 77109 (Kurz), Andaman islands. Andaman islands.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, medium in size; polar view circular, lobed, equatorial view elliptical; subprolate in shape.

Dimension: P: 30.5 – 36μ
E: 25.2 – 27μ

Mean value for acetolysed grains 33 × 26.6μ and for acetolysed and chlorinated grains 35.6 × 27.7μ distance between widely separated furrow apices 6μ

Aperture: 3-colporate, colpi 3, about 25 μ long and 3μ broad, taper gradually towards the poles; ora 3, one in the middle for each furrow, lalongate, elliptical 2 × 8μ, membrane smooth.

Exine: Thick, 3.5μ; sexine thicker than nexine, sexine about 2.5μ thick; surface pattern coarsely reticulate, heterobrochate, simplibaculate to duplibaculate, meshes about 4μ or large.

Polar field index: 1:4.4, small.

Picrasma javanica Bl.

Scheme: 12; Pl. III, Figs. 47-50

Source and *distribution* CNH 77035 (Dinghoo), Sikkim; ECH 4343 (Daka), Khasia and Jaintia hills. Sikkim Himalayas, Assam, Andaman islands.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, medium in size; polar view circular, 3-lobed, equatorial view elliptical; subprolate (65%) to prolate spheroidal in shape.

Dimension: P: 27.2 – 33.6 μ
E: 22.4 – 27.2 μ

Mean value for the acetolysed grains 29.7 × 25μ and acetolysed and chlorinated grains 31.6 × 25μ; distance between widely separated furrow apices 6.5μ.

Aperture: 3-colporate, colpi 3, about 24μ long and 3.2μ broad, taper towards the poles, tenuimarginate; ora 3, one in the middle of each furrow, lalongate, elliptical 2 × 8μ, membrane smooth.

Exine: Thick, 3 μ, sexine thicker than nexine, sexine 2 μ thick, surface pattern coarsely reticulate, reticulation near the colpi margin rather small, tectate, simplibaculate, columellate.

Polar field index: 1:3.8, medium.

Picrasma nepalensis Benn.

Scheme: 13; Pl. III, Figs. 51-53

Source and *distribution*: CNH 77092 (Peal), Sibsagar, Assam; ECH 4353 (Sarma), Khasia and Jaintia hills. Nepal, Sikkim Himalayas, Bengal, Assam, Sambalpur.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, medium in size; polar view almost circular, shallowly lobed, equatorial view elliptical; subprolate (60%) to prolate spheroidal.

Dimension: P: 33.6 – 41.6μ
E: 25.6 – 33.6μ

Mean value for acetolysed grains 35.5 × 30.7μ and for acetolysed and chlorinated grains 39.6 × 31.7μ; distance between widely separated furrow apices 6μ.

Aperture: 3-colporate, colpi 3, about 28μ long and 5μ broad, taper gradually towards the poles; ora 3, one in the middle of each furrow, elliptical lalongate, 1.6 × 8μ, membrane smooth.

Exine: Thick about 4μ, sexine thicker than nexine, sexine 2.5μ, surface pattern coarsely reticulate, irregularly polygonal, about 3.5μ, reticulation near the colpi margins small, simplibaculate, synpilate.

Polar field index: 1:5.1, small.

Picrasma quassioides Benn.

Scheme: 14; Pl. III, Figs. 54-58

Source and *distribution*: CNH 77015 (Lace), Chamba. North Garhwal, Kulu, Nepal, Eastern Himalayas, Bhutan, Khasia hills.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, medium in size; polar view almost circular, shallowly lobed, equatorial view elliptical to subspherical; subprolate to prolate spheroidal in shape.

Dimension: P: $34-42.5\,\mu$
E: $27.2-34\,\mu$

Mean value for the acetolysed grains $37.5 \times 31.5\,\mu$; distance between widely separated furrow apices $10\,\mu$.

Aperture: 3-colporate, colpi 3, about $25\,\mu$ long and $2.5\,\mu$ broad, tip acute; ora 3, one in the middle of each furrow, elliptical lalongate, $3 \times 10\,\mu$, membrane smooth.

Exine: Thick about $3\,\mu$ sexine thicker than nexine, sexine $2\,\mu$; surface pattern coarsely reticulate, irregularly polygonal, meshes about $3\,\mu$, homobrochate, simplibaculate.

Polar field index: 1:3.1, medium.

Quassia amara L.

Scheme: 15; Pl. III. Figs. 59-60; Pl. IV. Figs. 61-63

Source and *distribution*: CNH 76896, cultivated in Indian Botanic Garden. Cultivated plant.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, medium in size; triangular in polar view, angulaperturate, equatorial view elliptical, polar axis short; suboblate in shape.

Dimension: P : $34-37.8\,\mu$
E : $37-42\,\mu$

Mean value for the acetolysed grains $36 \times 40.5\,\mu$; distance between widely separated furrow apices $4\,\mu$

Aperture: 3-colporate, colpi 3, narrow $28\,\mu$ long and $2\,\mu$ broad, taper gradually at the tips; ora 3, not clear, one in the middle of each furrow, square with irregular margin, $9 \times 9\,\mu$, membrane smooth.

Exine: Thick $2.5\,\mu$; sexine as thick as the nexine, surface pattern striato-reticulate, slightly curvimurate, pattern almost striate near the colpi margins.

Polar field index: 1 : 10, very small.

Samadera indica Gaertn.

Pl. IV. Fig. 65.

Source and *distribution*: CNH 76987 (Haviland), Borneo. Bombay, Konkan, Malabar, Travancore, Madras.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, small in size; polar view circular to subtriangular, equatorial view almost spherical; prolate spheroidal in shape.

Dimension: P : $21.6-25.2\,\mu$
E: $21-23.4\,\mu$

Mean value for acetolysed grains $23 \times 21.7\,\mu$ and for actolysed and chlorinated grains $24.3 \times 23.4\,\mu$; distance between widely separated furrow apices $7\,\mu$.

Aperture: 3-colporate, colpi 3, about $15\,\mu$ long and $2\,\mu$ broad; ora 3 lalongate, $4 \times 8\,\mu$, elliptical, ends rounded, membrane smooth.

Exine: Thick $2.5\,\mu$, sexine thicker than or sometime as thick as nexine; surface pattern distinctly reticulate, heterobrochate, obscurely duplibaculate, meshes about $1.5\,\mu$.

Polar field index: 1 : 3.1, medium.

Samadera indica var. **lucida** Blatter (S. *lucida* Benn.)

Scheme : 16; Pl. IV. Fig. 64

Source and *distribution*: CNH 76990, Burma. Andaman islands, Burma.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, small in size; polar view circular to subcircular, shallowly lobed, equatorial view subspherical; prolate spheroidal (80%) to subprolate in shape.

Dimension: P : $22.4-28\,\mu$
E: $21-24\,\mu$

Mean value for acetolysed grains $24.3 \times 22.4\,\mu$; distance between widely separated furrow apices $7\,\mu$.

Aperture: 3-colporate, colpi 3, about $18\,\mu$ long, and $1.6\,\mu$ broad, tip acute, colpi with indistinct margins; ora 3, elliptical, lalongate, $4 \times 10\,\mu$, membrane smooth.

Exine: Thick, $2.5\,\mu$; sexine thicker than nexine or rarely as thick as nexine; surface pattern distinctly reticulate, tectate, heterobrochate, duplibaculate, meshes about $2\,\mu$.

Polar field index: 1 : 3.2, medium.

Suriana maritima L.

Scheme : 17; Pl. IV. Figs. 66-69

Source and *distribution*: CNH 77299 (H.M.I.M. investigator), Laccadive islands, Wadhwa 48908, Laccadive islands. Throughout tropical shores of India.

Symmetry and form: Pollen grain isopolar, 3-zonicolporate, medium in size, polar view triangular, angulaperturate, sides straight, equatorial view elliptical, polar axis short, suboblate in shape.

Dimension: P : $28-34\,\mu$
E : $39-42\,\mu$

Mean value for acetolysed grains $30 \times 40\,\mu$, distance between widely separated furrow apices $9\,\mu$.

Aperture: 3-colporate, colpi 3, $25\,\mu$ long and $2\,\mu$ broad, long, narrow, taper gradually towards the tips; ora 3, one in the middle of each furrow, distinctly square, $7 \times 7\,\mu$, (Similar type of ora as in *Irvingia* and *Quassia*).

Exine: Thick, $2.5\,\mu$; sexine slightly thicker than nexine; surface pattern finely striate, columella about $1\,\mu$.

Polar field index: 1 : 4.5, small.

Variation: CNH 77299. Pollen grains are larger in size; Mean value for acetolysed grains $42 \times 48\,\mu$.

KEY TO GENERA

Grains isopolar, uniformly 3-zonicolporate, usually medium to small in size, circular and subtriangular to triangular in polar view, subspherical to elliptical in equatorial view, suboblate and spheroidal to prolate in shape (longest axis 17.6μ in *Eurycoma apiculata* and 52 μ in *Harrisonia bennetti*), and without spines. Exine is two layered with sexine thicker than or sometimes as thick as nexine. Colpi are long narrow and tapering with lalongate to square ora and smooth membrane.

A. *Amb circular in polar view : planaperturate*	
B. *Exine reticulate, ora lalongate*	
a. Grains below 40 μ	**Picrasma** 1. *P. andamanica* 2. *P. javanica* 3. *P. nepalensis* 4. *P. quassioides*
b. Grains over 44 μ	**Harrisonia** 5. *H. bennetti*
c. Grains below 25 μ	**Samadera** 6. *S. indica* 7. *S. indica* var. *lucida*
BB. *Exine striate*	
a. Grains about 30 μ ora more or less lolongate	**Balanites** 8. *B. aegyptica*
b. Grains below 25 μ, ora lalongate	**Brucea** 9. *B. mollis* 10. *B. amarissima*
AA. *Amb subtriangular almost hexagonal, colpi situated at the middle of the flat angles, ora lalongate.*	
B. *Exine reticulate*	
a. Grains about 35 μ	**Ailanthus** 11. *A. altissima* 12. *A. triphysa*
b. Grains below 25 μ, more or less angulaperturate	**Eurycoma** 13. *E. apiculata* 14. *E. longifolia*
BB. *Exine striato reticulate*	
a. Grains about 35 μ	**Ailanthus** 15. *A. excelsa*
AAA. *Amb triangular ; angulaperturate, ora square*	
B. *Exine reticulate*	
a. Grains below 25 μ	**Irvingia** 16. *I. malayana*
BB. *Exine striate*	
a. Grains about 40 μ	**Suriana** 17. *S. maritima*
BBB. *Exine striato-reticulate*	
a. Grains about 40 μ, ora more or less square with irregular margins	**Quassia** 18. *Q. amara*

DISCUSSION AND CONCLUSION

The study on the pollen morphology of 10 genera comprising of 18 species of the family Simaroubaceae reveals that pollen grains in the family are more or less of uniform type. Grains are usually 3-zonicolporate, medium to small in size, with narrow, long and tapering colpi, circular and subtriangular to triangular in polar view, suboblate and spheroidal to prolate in shape, and without spines. The exine is two-layered with sexine as thick as or thicker than nexine. Surface pattern of the grain is reticulate to striate and striato-reticulate. The polar field index ranges between 1 : 2 to 1 : 5.3 and the corresponding size of the polar field varies from medium to small.

Whether acetolysed or chlorinated the structural pattern of pollen remains constant. But depending upon the nature of treatment, the size and the shape class vary in pollen from the same herbarium sheet. When chlorinated, the length of the polar axis is markedly increased and the equatorial axis is usually less affected (Duigan, 1961). Grains of *Ailanthus* and *Picrasma* show a wide range of variation in this respect. It has also been observed that pollen grains of a species collected from different locality tend to vary considerably in certain cases as in *Ailanthus triphysa, Balanites aegyptica, Picrasma javanica* and others. Here also the deviation was noted in shape class, general size of the grain and in measurements of colpi and ora. This natural variation within a species is interesting and very common in tropical flora (Guinet, 1962).

In order to compare the differences in pollen size and to study the range of variation within a species, the length of polar axis and equatorial axis of an individual species is plotted on rectangular coordinates. The limit of distribution of a species is obtained by an enclosing line, drawn after plotting a sufficient number of pollen grains. It shows that the majority of species studied, falls between the iso-ratio line of 1 to 1.5. The ratio seems to depend on the polar axis of the grain (Fasbender, 1959; Ting, 1961). *Suriana* and *Quassia* are distinct in this respect as they are separated between the iso-ratio line of 1 - 0.75.

It is evident from the dimensional diagram and from the characteristic features as summerized in the table No. I, that the family consists of closely related species with a homogeneous group of pollen. But constant differences in some characters of the pollen make it possible to recognise the grains of certain genera and species. Based on these well marked characters, a key to the genera of Indian Simaroubaceae has been prepared. In some genera like *Ailanthus* (in part), *Brucea*, *Eurycoma* and *Picrasma* the identification upto the species on the basis of pollen characters seems rather difficult.

It is also evident from the summary of morphological characters and metrical data of the family that two distinct pollen types can easily be recognized in the species studied here. The first type (*Ailanthus* type) is characterised by the elliptical to spherical grains with circular to subcircular amb, distinctly lalongate ora and commonly reticulate surface pattern. Majority of the species investigated fall under this group. The other type is characterised by elliptical grains with angulaperturate triangular amb and square type of ora as represented by *Irvingia, Quassia* and *Suriana.*

Taxonomical consideration: Brizicky (1962) considers Simaroubaceae as a heterogeneous family. He, however, prefers to retain the family in a large sense because of the absence of sufficient data from anatomy, cytology and embryology.

Wilson (1911), Small (1911) and Record and Hess (1943) consider that *Suriana* represents a distinct monotypic family Surianaceae. Gutzwiller (1961) has concluded that *Suriana* shows distinct affinities with Chrysobalanaceae, Connaraceae and Sapindaceae of Geraniales and should represent a separate family. On evidences from wood anatomy, Metcalfe and Chalk (1950) have supported the transfer of *Irvingia* into a separate family. *Balanites* has long been recognised as a member of different families on various morphological grounds. It has been placed by Bentham and Hooker (1862) in the Simaroubaceae and by Engler (1931) in the Zygophyllaceae. Hutchinson (1959) and others have made it the type of a special family Balanitaceae. From a study of floral morphology and embryology of the genus, Nair and Jain (1956) have concluded that *Balanites* has no close connection with either Simaroubaceae or Zygophyllaceae. But the present palynological investigation on the Indian taxa of Simaroubaceae does not provide any evidence in favour of such transfers.

Pollen grain of *Suriana maritima* resembles *Quassia amara,* particularly in size, shape class, colpi and ora. The square type of ora in *Suriana* and *Quassia* are also noticed in *Irvingia malayana.* In the nature of reticulation and strucural pattern of the grain, *Irvingia malayana* is closely related to the main part of the family. Thus palynological studies do not support the separation of *Suriana* and *Irvingia* from the family Simaroubaceae. (cf. Erdtman, 1952).

Pollen character of *Balanites* also presents a resemblance to other members of Simaroubaceae (cf. Erdtman, 1952). More or less lolongate ora and striate pollen sculpturing characterise the pollen type in *Balanites aegyptica.* Striate type of grain is rare in Zygophyllaceae. But Simaroubaceae shows the presence of striate grains in genera like *Suriana* and *Brucea* and striato-reticulate grain in *Quassia* studied here. So morphologically pollen of *Balanites* shows a close affinity to Simaroubaceae. A similar view that the systematic position of *Balanites* is in Simaroubaceae is held by Paris and Aubrat (1946).

Bennett (1875) considers *Samadera indica* and *S. lucida* as two distinct species. Blatter (1935) includes *S. lucida* under *S. indica* as a variety only. A comparison of the pollen characters of these taxa shows that there is no difference in their structural patterns. Pollen morphology thus supports Blatter's view.

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LITERATURE CITED

ANONYMOUS. Towards terminological unification in pollen and spore morphology. *Grana Palynol.* 1(3) : 3-5. 1958.

BENNETT, A. W. Simaroubaceae in J. D. Hooker's *Flora of British India* 1 : 517-523. London. 1875.

BENTHAM, G. AND J. D. HOOKER. *Genera Plantarum* 1(1) : 314. 1862.

BLATTER, E. Simaroubaceae in Kirtikar and Basu's *Indian Medicinal Plant* 1 : 509. Allahabad, 1935.

BRIZICKY, G. K. The genera of Simaroubaceae and Burseraceae in South-eastern United States. *J. Arnold Arb.* 43(2) : 173-186. 1962.

DUIGAN, S. L. Studies of the pollen grains of plants native to Victoria, Australia. I. Goodeniaceae (including *Brunonia*) *Proc. roy. Soc. Vict.* 74(3) : 87-109. 1961.

ENGLER, A. Simarubaceae in Engler and Prantl's *Die Nat. Pflanzenfam.* ed. 2 : 19a : 359-405, Leipzig, 1931.

ERDTMAN, G. *Pollen morphology and Plant taxonomy* I. *Angiosperms.* Stockholm, 1952.

—— Pollen walls and angiosperm phylogeny. *Bot. Not.* 113(1) : 41-45. 1960a.

—— The acetolysis method. A revised description. *Svensk bot. Tidskr.* 54(4) : 561-564. 1960b.

—— Pollen walls and angiosperm phylogeny. *Recent advances in Botany* 1 : 675-678. Canada, 1961.

—— AND J. PRAGLOWSKI. Six notes on pollen morphology and pollen morphological techniques. *Bot. Not.* 112 : 175-184. 1959.

—— AND H. STRAKA. Cormophyte spores classification. An outline based on the apertures (tremata). *Geol. Fören. Stockh. Forh.* 83 : 65-67. 1961.

—— AND VISHNU-MITTRE. On terminology in pollen and spore morphology. *Grana Palynol.* 1(3) : 6-9. 1958.

FAEGRI, K. Recent trends in Palynology. *Bot. Rev.* 22 : 639-664. 1956.

Faegri, K. and J. Iverson. *Text book of modern pollen analysis.* Copenhagen, 1950.

Fasbender, M. V. Pollen grain morphology and its taxonomic significance in the Amherstieae, Cynometreae and Sclerolobieae (Caesalpinaceae) with special reference to American genera. *Lloydia* 22 (2) : 107-162. 1959.

Griebel, C. Zur mikroskopischen Pollenanalyse des Honigs. *Z. untersuch. Lebensmitt.* 61. 1931.

Guinet, Ph. Pollens d'Asie tropicale, Fascicule I. *Inst. Fr. Pondicherry, Trav. Sect. Sci. Tech. Hors Serie* 5 : 1-8, 52 Plates, 1962.

Gutzwiller, M. A. Die phylogenetische stellung von. *Suriana maritima* L. (Simaroubaceae) *Bot. Jb.* 81 : 1-49. 1961.

Hyde, H. A. and K. F. Adams. *An atlas of airborne pollens.* London, 1958.

Hutchinson, J. *The families of flowering plants* I. *Dicotyledons.* London, 1959.

Ikuse, M. *Pollen grains of Japan.* Tokyo, 1956.

Iverson, J. and J. Troels-Smith. Pollenmorphologiske definitioner og typer. *Geol. Unders.* IV Raekke, 3(8) : 1-54, 1950.

KupriaNova, L. A. On a hitherto undescribed family belonging to the Amentiferae (Carpinaceae) *Taxon* : 12(1) : 12-13. 1963.

Lawrence, G. *Taxonomy of vascular plants.* Simaroubaceae 558-559. New York, 1951.

Metcalfe, C. R. and L. Chalk. *Anatomy of the dicotyledons.* Simaroubaceae 317-325. Oxford, 1950.

Nair, N. C. and R. K. Jain. Floral morphology and embryology of *Balanites roxburghii* Planch. *Lloydia* 12(4) : 269-279, 1956.

Paris, R. and Mue M.-Y. Aubrat. "Le genere *Balanites* ses affinites et sa place en systematique" *Bull. Soc. bot. Fr.* 93 : 202. 1946.

Punt, W. Pollen morphology of the Euphorbiaceae with special reference to taxonomy. *Wentia* 7 : 1-116. 1962.

Record, S. J. and R. W. Hess. *Timbers of the New World.* Surianaceae. 521-522. New Haven, 1943.

Selling, O. *Studies in Hawaiian Pollen statistics.* II. *The pollens of the Hawaiian phanerogams. Spec. publ. Bishop Mus.* 38 : Gothenburg, 1947.

Small, J. K. Simaroubaceae. *N. Am. Fl.* 25 : 227-239. 1911.

Ting, W. S. On some pollen of Californian Umbelliferae. *Pollen et Spores* 3(2) : 189-199. 1961.

Wilson, P. Surianaceae. *N. Am. Fl.* 25 : 225. 1911.

Wodehouse, R. P. Tertiary pollen I. Pollen of the living representatives of the Green River flora. *Bull. Torrey bot. Cl.* 59 : 313-340. 1932.

—— *Pollen Grains.* New York, 1935.

—— *Atmospheric pollen. Aeriobiology Publ. Amer. Ass. adv. Sci.* 17 : 1942.

—— *Hayfever plants.* Waltham, Mass., 1945.

Zander, E. *Beiträge zur Harkunftsbestimmung bei Honig.* I-III. *Pollengestaltung und Herkunftsbestimmung bei Blüthenhonig.* I. Berlin, 1935 II. Leipzig, 1937 III. Leipzig, 1941.

EXPLANATION TO PLATES

Plate I

1.	*Ailanthus altissima*	CNH 76901	Equatorial view
2.	,, ,,	,,	Polar view
3.	,, ,,	,,	Equatorial optical section
4.	,, ,,	,,	Polar view showing reticulation
5.	*A. triphysa*	Arora 760	Equatorial vew
6.	,, ,,	,,	Equatorial view showing os
7.	,, ,,	,,	Equatorial view showing intercolpium region.
8.	,, ,,	CNH 76931	Equatorial view
9.	,, ,,	,,	Polar view
10.	,, ,,	,,	Polar view showing. reticulation

11.	*A. triphysa*	CNH 76931	Equatorial optical section
12.	*A. excelsa*	CNH 76903	Equatorial view (short axis grain)
13.	,, ,,	,,	Polar view
14.	,, ,,	,,	Equatorial optical section
15.	*Balanites aegyptica*	CNH 77402	Equatorial view
16.	,, ,,	,,	Equatorial view showing intercolpium
17.	,, ,,	,,	Equatorial optical section
18.	*Brucea mollis*	CNH 4326	Equatorial view
19.	,, ,,	,,	Equatorial view showing aperture.
20.	,, ,,	,,	Equatorial optical section

Plate II

21.	*Brucea amarissima*	CNH 77166	Equatorial view
22.	,, ,,	,,	Equatorial view at lower level
23.	,, ,,	,,	Equatorial view showing inter-colpium
24.	,, ,,	,,	Equatorial optical section
25.	*Eurycoma apiculata*	CNH 77281	Equatorial view showing os.
26.	,, ,,	,,	Polar view showing reticulation
27.	,, ,,	,,	Equatorial optical section
28.	,, longifolia	CNH 77246	Equatorial view
29.	,, ,,	,,	Polar view
30.	,, ,,	,,	Equatorial optical section

31.	*Harrisonia bennetti*	CNH 77332	Equatorial view
32.	,, ,,	,,	Equatorial view showing aperture
33.	,, ,,	,,	Axial optical section
34.	,, ,,	ECH 4303	Equatorial view showing intercolpium
35.	,, ,,	,,	Equatorial view showing reticulation
36.	,, ,,	,,	Same at different foci
37.	,, ,,	,,	Equatorial optical section
38.	,, ,,	,,	Polar view
39.	*Irvingia malayana*	CNH 77317	Equatorial view
40.	,, ,,	CNH 77330	Equatorial view showing intercolpium

PLATE III

41.	*Irvingia malayana*	CNH 77330	Equatorial view showing colpus
42.	,, ,,	,,	Equatorial view showing os
43.	,, ,,	,,	Polar view
44.	,, ,,	,,	Equatorial optical section
45.	,, ,,	,,	Polar view of a tetracolporate grain
46.	*Picrasma andamanica*	CNH 77109	Equatorial view showing reticulation
47.	*P. javanica*	CNH 77035	Equatorial view
48.	,, ,,	,,	Equatorial view showing reticulation
49.	,, ,,	,,	Axial optical section
50.	,, ,,	,,	Polar view
51.	*P. nepalensis*	ECH 4353	Equatorial view showing reticulation
52.	*P. nepalensis*	ECH 4353	Equatorial view showing 'LO' analysis
53.	,, ,,	,,	Axial optical section
54.	,, ,,	,,	Equatorial view
55.	,, ,,	,,	Equatorial view showing os
56.	,, ,,	,,	Polar view showing reticulation
57.	,, ,,	,,	Polar view showing columella
58.	,, ,,	,,	Equatorial optical section
59.	*Quassia amara*	CNH 76896	Equatorial view
60.	,, ,,	,,	Equatorial view showing striae on the colpi margin

PLATE IV

61.	*Qussia amara*	CNH 76986	Equatorial view showing striation on colpi margin at lower view
62.	,, ,,	,,	Polar view
63.	,, ,,	,,	Polar view showing reticulation
64.	*Samadera indica* var. *lucida*	CNH 76990	Equatorial view
65.	*Samadera indica*	CNH 76987	Polar view
66.	*Suriana maritima*	CNH 77299	Equatorial view
67.	,, ,,	,,	Equatorial view showing os
68.	,, ,,	,,	Polar view
69.	,, ,,	,,	Polar view showing striation

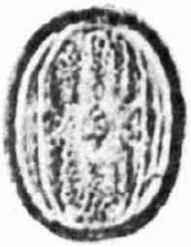
PLATE V

1. *Ailanthus altissima*
2. *A. triphysa*
3. *A. excelsa*
4. *Balanites aegyptica*
5. *Brucea mollis*
6. *B. amarissima*
7. *Eurycoma apiculata*
8. *E. longifolia*
9. *Harrisonia bennetti*
10. *Irvingia malayana*
11. *Picrasma andamanica*
12. *P. javanica*
13. *P. nepalensis*
14. *P. quassioides*
15. *Quassia amara*
16. *Samadera indica*
17. *Suriana maritima*

PLATE VI

Abbreviations used : Aa—*Ailanthus altissima* ; At—*A. triphysa* ; Ae—*A. excelsa* ; B—*Balanites aegyptica* ; Bm—*Brucea mollis* ; Ba—*B. amarissima* ; Ea—*Eurycoma apiculata* ; El—*E. longifolia* ; H—*Harrisonia bennetti* ; I—*Irvingia malayana* ; Pa—*Picrasma andamanica* ; Pj—*P. javanica* ; Pn—*P. nepalensis* ; Pq—*P. quassioides* ; Q—*Quassia amara* ; Si—*Samadera indica* ; Sl—*S. indica* var. *lucida* ; S—*Suriana maritima.*

PLATE 1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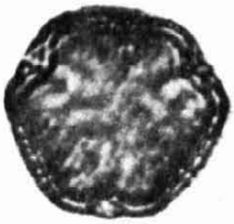
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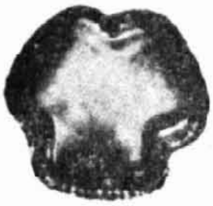
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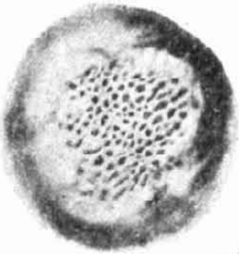
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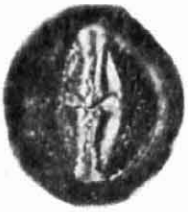
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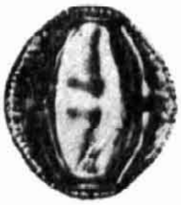
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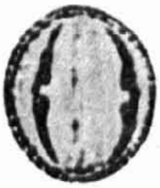
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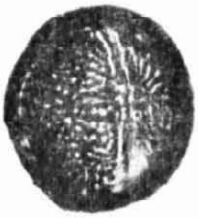
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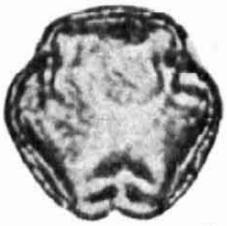
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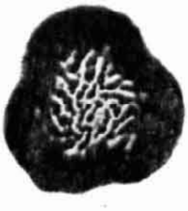
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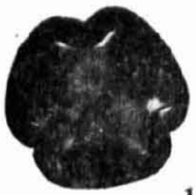
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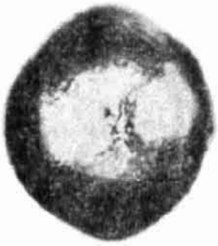
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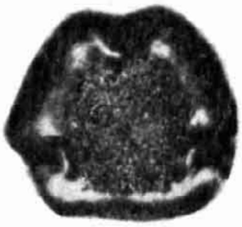
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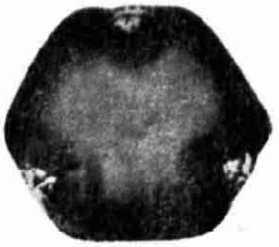
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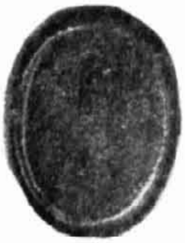
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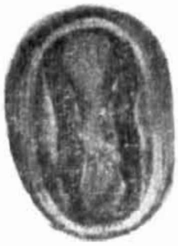
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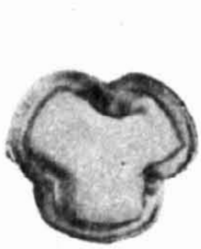
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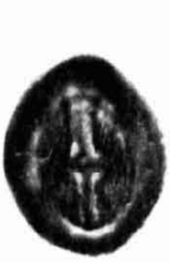
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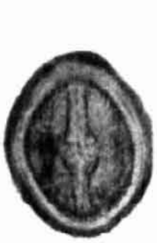
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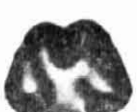
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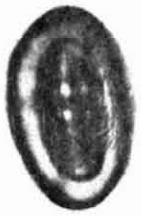
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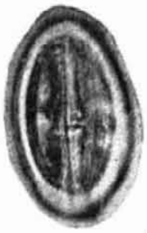
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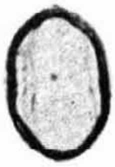
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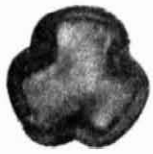
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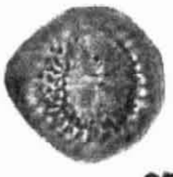
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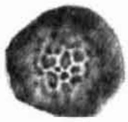
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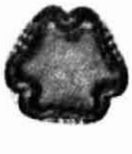
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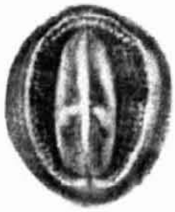
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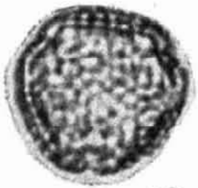
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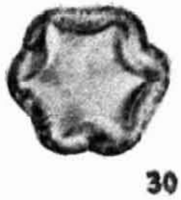
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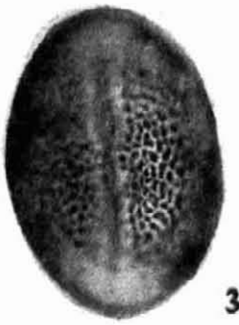
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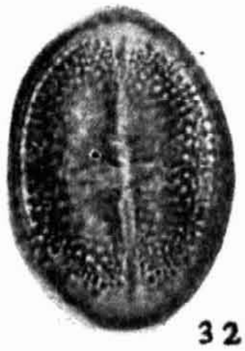
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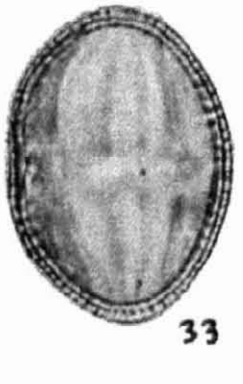
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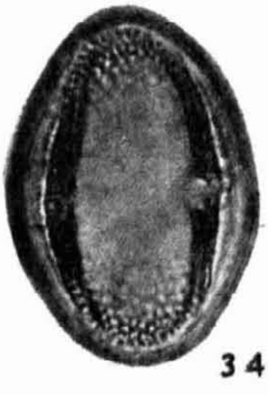
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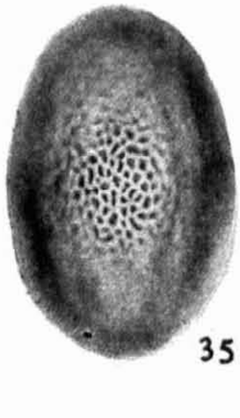
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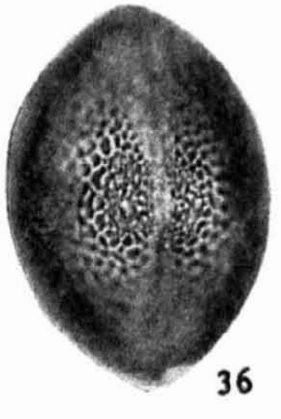
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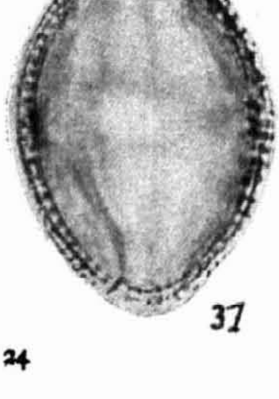
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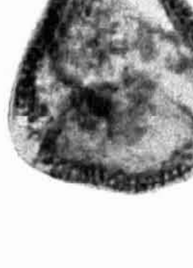
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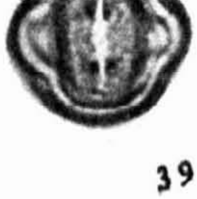
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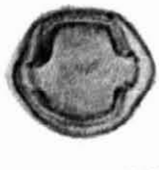
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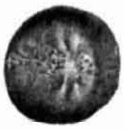
PLATE III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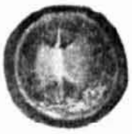
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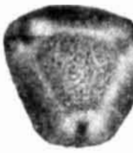
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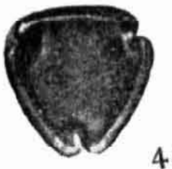
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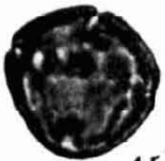
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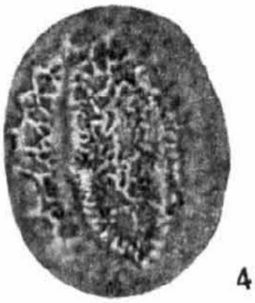
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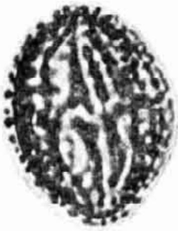
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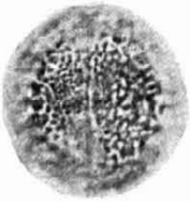
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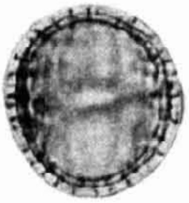
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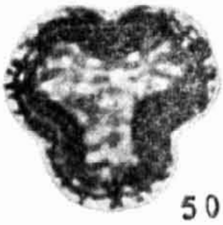
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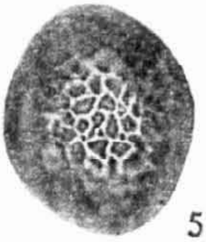
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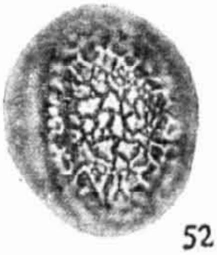
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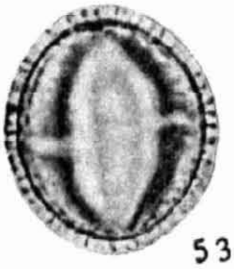
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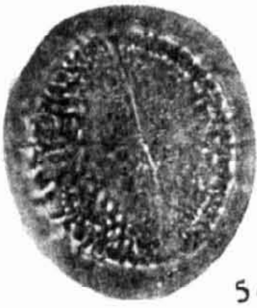
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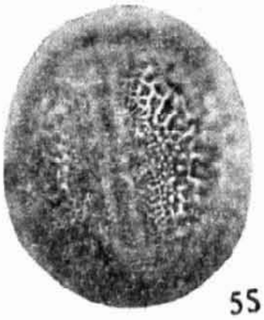
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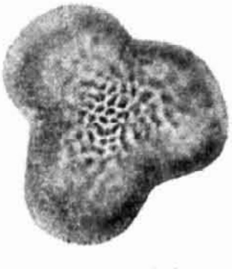
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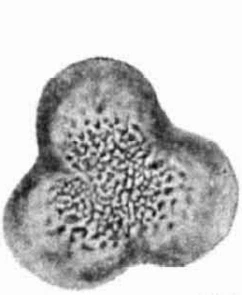
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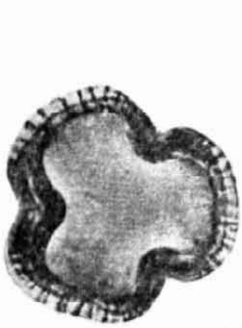
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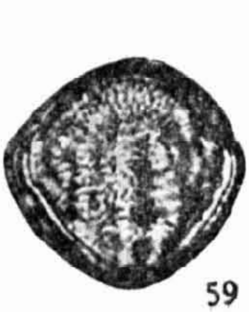
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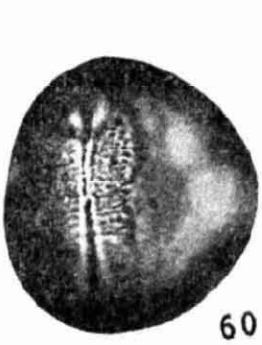
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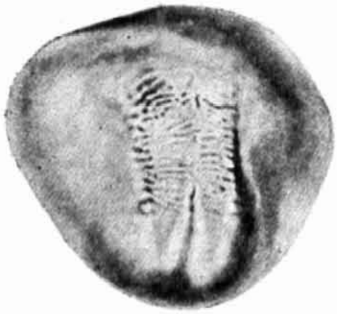
PLATE IV



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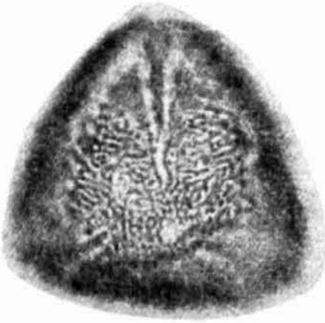

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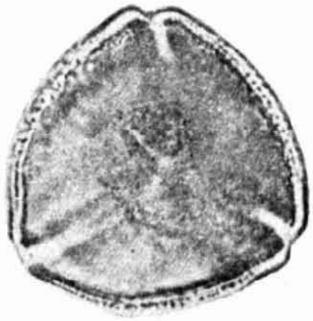

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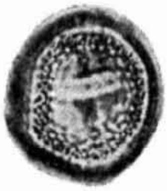

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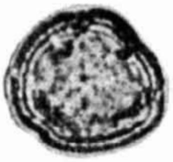

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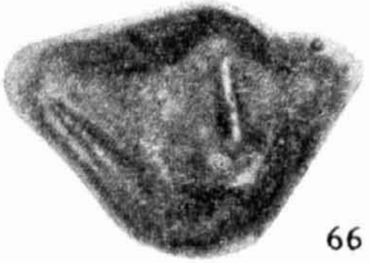

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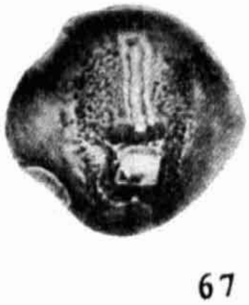

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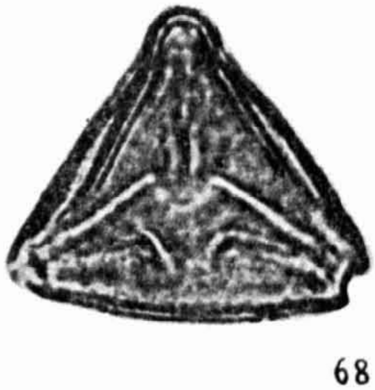

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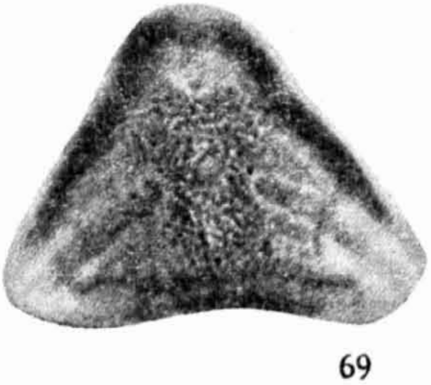

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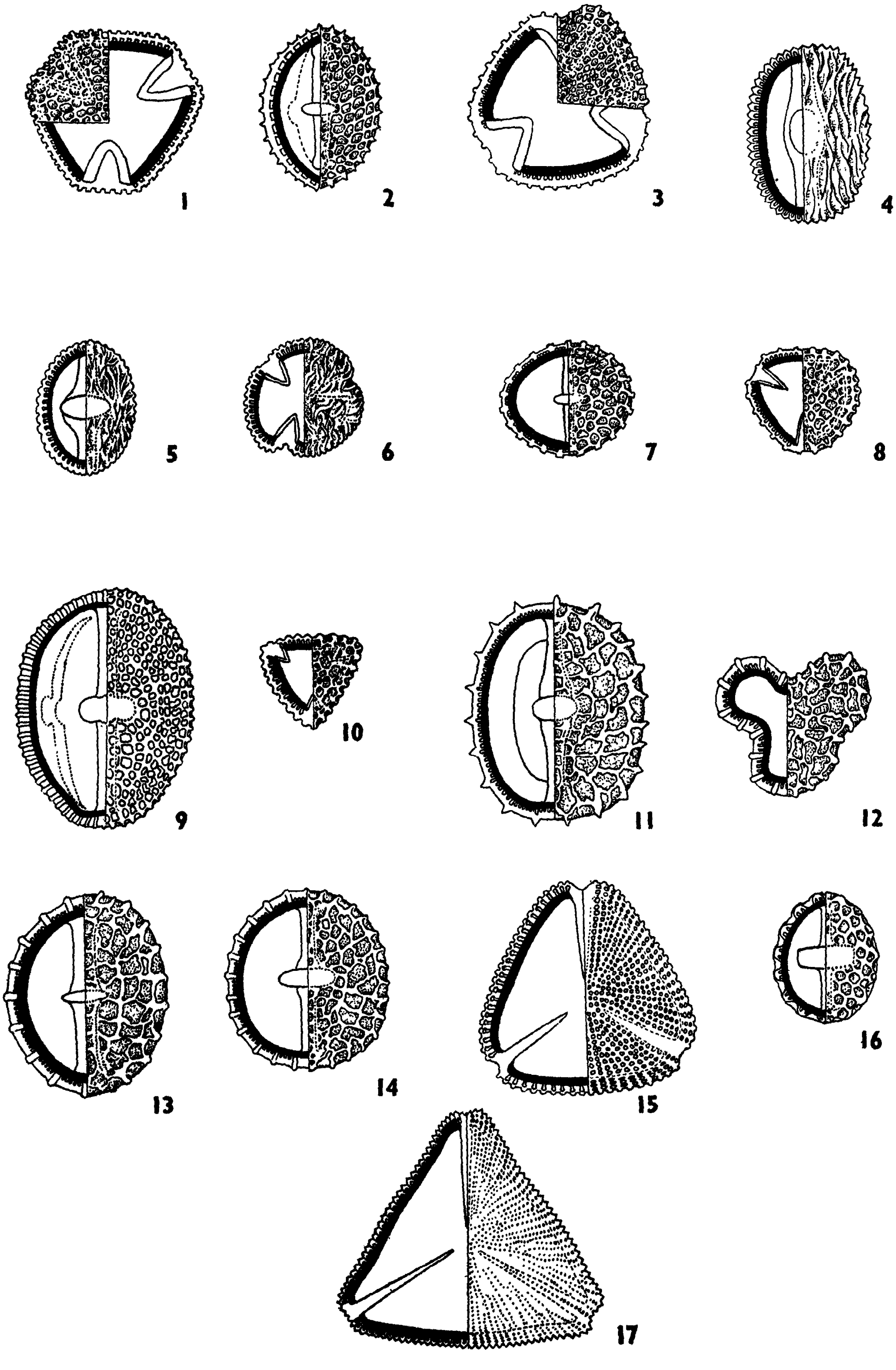

Plate V : Schematic Structure of Pollen Grains of Indian Simaroubaceae × 1000.

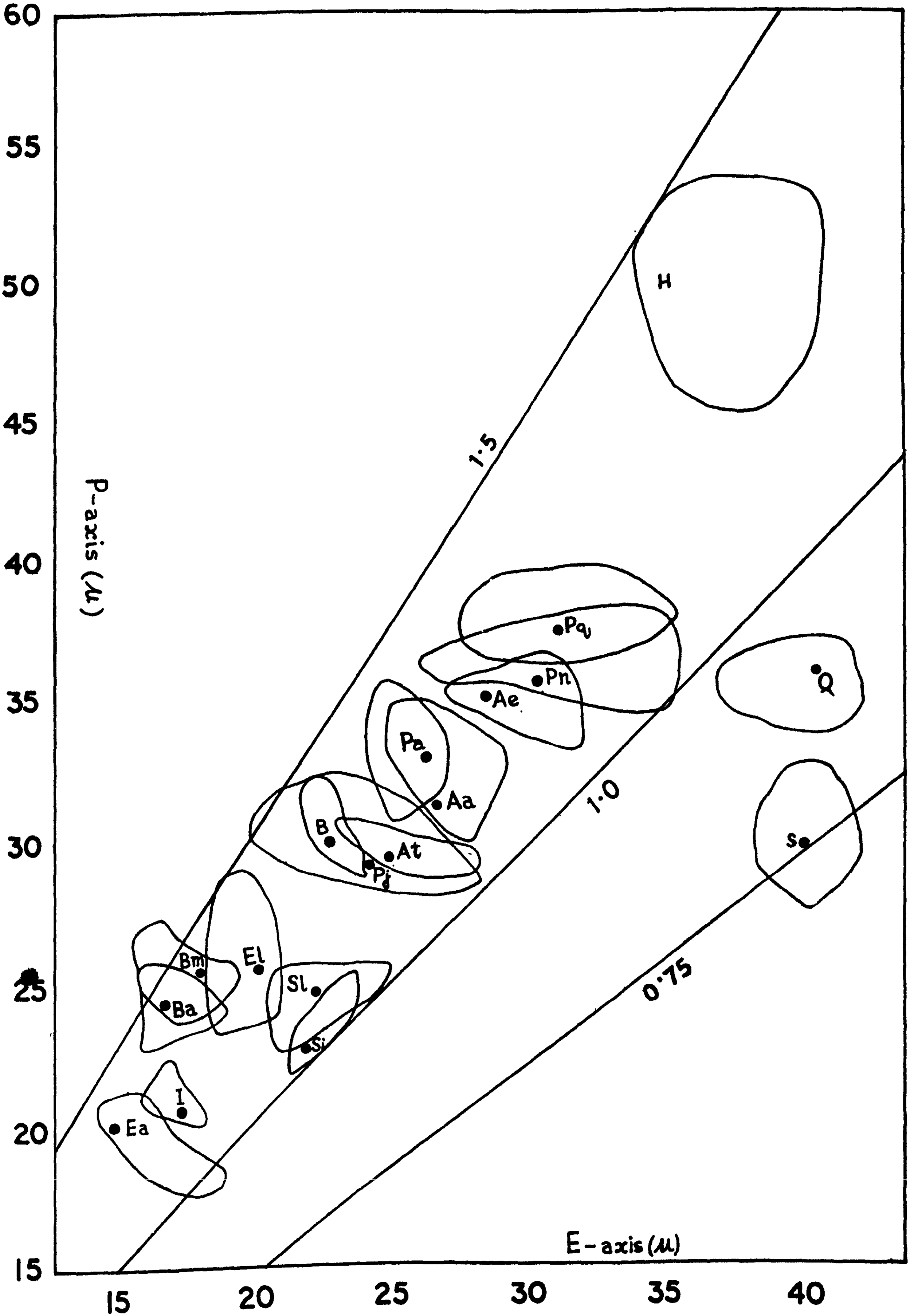

PLATE VI : Dimensional diagram showing size variations in Pollen Grains.

SUMMARY OF MORPHOLOGICAL CHARACTERS AND METRICAL

Name of the species	Size range in microns		Shape class
	P	E	
1	2	3	4
1. *Ailanthus altissima* (Mill.) Swingle	27-**31.7**-36	24-**26.7**-30	prolate spheroidal (70%) to subprolate
2. *A. triphysa* (Dennst.) Alston	27.2-**28.9**-32	24-**25.3**-28.8	prolate spheroidal (70%) to subprolate
3. *A. excelsa* Roxb.	33.6-**35.4**-40	24-**29**-32	subprolate (70%) to prolate spheroidal
4. *Balanites aegyptics* (L.) Delile	28-**30**-32	21-**23**-26.5	subprolate (85%) to prolate
5. *Brucea mollis* Wall.	24-**25**-27	16-**18.5**-21	prolate (60%) to subprolate
6. *B. amarissima* (Lour.) Merr.	22.4-**24**-27.2	16-**16.4**-19.2	prolate
7. *Eurycoma apiculata* Benn.	17.6-**18.8**-20.8	13-**14.8**-19.2	prolate (70%) to subprolate
8. *E. longifolia* Jack.	23-**25.8**-28.8	17.6-**20.6**-22.4	subprolate (80%) to prolate
9. *Harrisonia bennetti* Hk. f.	45-**49.5**-52	32-**33.8**-38	prolate
10. *Irvingia malayana* Oliv.	18-**20**-22	16-**18**-20	prolate spheroidal (90%)
11. *Picrasma andamanica* Kurz	30.5-**33**-36	25.2-**26.6**-27	subprolate
12. *P. javanica* Bl.	27.2-**29.7**-33.6	22.4-**25**-27.2	subprolate (65%) to prolate spheroidal
13. *P. nepalensis* Benn.	33.6-**35.5**-41.6	25.6-**30.7**-33.6	subprolate (60%) to prolate spheroidal
14. *P. quassioides* Benn.	34-**37.5**-42.5	27.2-**31.5**-34	subprolate to prolate spheroidal
15. *Quassia amara* Linn.	34-**36**-37.8	37-**40.5**-42	suboblate
16. *Samadera indica* Linn.	21.6-**23**-25.2	21-**21.7**-23.4	prolate spheroidal
17. *S. indica* Gaertn. var. *lucida* Blatter	22.4-**24.3**-26	21-**22.4**-24	prolate spheroidal (80%) to subprolate
18. *Suriana maritima* Linn.	28-**30**-34	39-**40**-41.5	suboblate

DATA OF THE POLLEN GRAINS OF SIMAROUBACEAE

Amb	Sexine pattern	os in microns	Exine thickness in microns	Polar field index
5	6	7	8	9
subtriangular	reticulate	lalongate 3 × 8	3, sexine as thick as nexine	medium 1 : 3
subtriangular	reticulate	lalongate 2.5 × 6.4	3.2, sexine thicker than nexine	medium 1 : 3.2
subtriangular	striato-reticulate	lalongate 3 × 10	3.4, sexine as thick as nexine	medium 1 : 3
circular	striate	lolongate 8 × 5	3, sexine as thick as nexine	medium 1 : 2.8
circular	striate	lalongate 3.5 × 6.4	2.5, sexine thicker than nexine	small 1 : 4
circular	striate	lalongate 3 × 7	2.5, sexine thicker than nexine	medium 1 : 3.5
subtriangular	reticulate	lalongate 1.5 × 5	2.5, sexine as thick as nexine	medium 1 : 1.8
subtriangular	reticulate	lalongate 3 × 6	2.5, sexine as thick as nexine or sometimes thicker	small 1 : 4.1
circular rarely subcircular	reticulate	lalongate 5 × 10	3, sexine thicker than nexine or sometimes as thick as nexine	medium 1 : 2.5
triangular	reticulate	square 5.4 × 7	3, sexine as thick as nexine or slightly thicker	medium 1 : 2.5
circular	reticulate	lalongate 2 × 8	3.5, sexine thicker than nexine	small 1 : 4.4
circular	reticulate	lalongate 2 × 8	3, sexine thicker than nexine	medium 1 : 3.8
circular	reticulate	lalongate 1.6 × 8	4, sexine thicker than nexine	small 1 : 5.1
circular	reticulate	lalongate 3 × 10	3, sexine thicker than nexine	medium 1 : 3.1
triangular	striato-reticulate	square 9 × 9	2.5, sexine as thick as nexine	very small 1 : 10
circular	reticulate	lalongate 4 × 8	2.5, sexine thicker than or as thick as nexine	medium 1 : 3.1
circular	reticulate	lalongate 4 × 10	2.5, sexine thicker or as thick as nexine	medium 1 : 3.2
triangular	striate	square 7 × 7	2.5, sexine slightly thicker than nexine	small 1 : 4.5